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DESIGNING AGRONOMIC PRACTICES
TO MEET
SPECIFIC EROSION HAZARDS

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The design of an agronomic program to meet erosion hazards may differ in vital respects from an agronomic program designed to secure crop production. It is obvious that preservation of the physical well-being of the soil results in improved production. However, the primary objectives in a program of soil and water conservation deal with the preservation of the physical properties of the land, and toward this aim the agronomy program, as well as other programs in the Soil Conservation Service, is primarily directed. To do so with the greatest efficiency, we need a careful analysis of the dominant factors comprising cause and effect. The target at which we shoot must be clearly defined. One of the ways by which the target may be more clearly defined is outlined herein.[1]

For the present discussion, let us confine our thinking to the problem of soil erosion resulting from rainfall. While this problem differs somewhat in its analysis from that of soil erosion resulting from melting snow or from erosion produced by wind, the principles of the analysis are the same for any one of them.

THE INTERACTION OF FORCES AND RESISTANCES

Erosion is the resultant of the interaction of certain forces and resistances. In erosion from rainfall we must deal with energies that often reach 2,000,000 foot-pounds per acre per storm. When this energy of rain impact is added to the further force of flowing turbulent water, severe erosion results unless protection in sufficient magnitude, and in proper time and frequency is provided.

Resistances to these forces are found in the vegetal or other cover that occurs upon the land at the time of the storm; in the inherent characteristics and condition of the soil; and in the various ways of impeding and retarding the flow of water on the land surface.

The agronomic practices are ordinarily the most feasible practices that the average farmer has at his command. They are likewise among the most effective measures for the control of erosion. The erosion-retarding effect of good cover on the land differs by as much as 1,000-fold from that of poor cover, this wide difference being due mostly to the so-called "umbrella" effects of a good vegetal canopy. Similar effects, however, come from dead vegetation used as mulch. Further protection is also provided in ways outlined in table 1, page 3, where the forces involved in rain and the resistances resulting from agronomic practices are given in skeleton form.

WHAT RAIN DOES

Rain provides energy of impact that abrades the soil, disperses the particles, and makes the soil particles more easily transportable. It is obvious that a single clay or silt particle is more easily transported than an aggregation of particles having a weight many times that of a single one. Then too, the rain that occurs in excess of the rate of infiltration provides water for overland flow and thus the means of transporting the loosened soil particles.

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[1] There are, of course, additional ways. The elements of the problem of control of runoff water was outlined as early as 1936 (see U. S. D. A. Tech. Bul. 558). Recently a method of using hydrologic data for the design of a terrace system was shown by D. D. Smith (see Agr. Engin., June 1948). Other workers have dealt with this problem at various times.

Furthermore, this excess rain--that is, the amount above that which infiltrates the soil--may produce rivulets, small channels, and gullies in which flowing water is highly turbulent and possesses great cutting power. This flowing stream or rivulet may loosen soil particles as well as transport them.

In the main these are the forces against which protection must be provided. We might go into greater detail and enumerate certain other forces that are contributing their effects, but because in most instances they are of small magnitude, the practical farm planner is justified in ignoring them.

WHAT AGRONOMIC PRACTICES CAN DO

Various well-designed agronomic practices will intercept the energy of rain impact. A dense cover of vegetation or a surface mulch of straw, or manure applied on the surface, are examples of practices that are extremely effective in intercepting the energy of rain impact. Many studies by many workers have clearly shown the importance of this ''umbrella'' effect.

These same agronomic practices also intercept a certain volume of water, so that less water reaches the ground surface than would be the case otherwise. From one-fourth to one-half an inch of rain may readily be held upon the leaves and stems of a dense cover. These dense types of vegetation also greatly modify the character and reduce the rate of overland flow. Where a dense vegetation exists, it has been shown by ample research evidence that the depth of water on the land surface is greater, turbulence is less, and the velocity of flow is spread out between the peak rates that otherwise would occur as a result of surges of the storm.

Because of the greater depth of water, during a storm, on land surface having dense vegetation, infiltration opportunity is increased. This is the case because surface water then covers more of the small vegetated hummocks that are present in any field. Many of these miniature hummocks that occur under small grass clumps, for example, are particularly permeable. Because of this increased infiltration opportunity, the amount of overland flow is less than would otherwise be the case. All of these above-mentioned effects of agronomic practices may be termed ''protective effects.'' They are the kinds of effects that are needed during the rain.

In addition to them, there are other results of crop and soil management that may be termed ''soil-conditioning effects.'' These soil-conditioning effects must be established before the rains occur. They may disappear in part during the course of the storm and are usually less effective upon the quantity of runoff and erosion than the treatments classified under ''protective'' in table 1, page 3, but they are nevertheless highly important. Among these effects are the results of organic matter and proper land treatment modifying soil permeability, soil aggregation, and particularly the stability of soil aggregates in the presence of water. All of these effects have been well established by the research of many different workers. In addition to those enumerated, there are still others which are of lesser magnitude normally and which, for purposes of brevity, we may ignore at the present time. It is important, however, to note that agronomic practices are the principal means by which the damage produced by the impact of intense rains may be modified on farm lands.

RAIN INTENSITY AND EROSION

Our research evidence shows clearly that in most instances the great proportion of erosion is the result of a small number of rains. In some cases as much as 80 percent of the annual soil losses may be attributed to a half dozen or so intense storms. In practically all cases, more than half of the annual erosion may be attributed to a small proportion of the total number of rains occurring during the year (table 2, page 3). By examination of the weather records for the locality, it is possible to identify the season or seasons of the year when these few erosion-producing storms usually occur.

Storms of intensities equaling or exceeding those which are starred in table 2 are those which have been termed by the Weather bureau ''excessive.'' In soil conservation work we

TABLE 1.--*The interaction of forces and resistances*

What rain does	What agronomic practices can do	
Provides energy to abrade, disperse, and erode soil.	(a) Intercept energy of rain (b) Intercept some volume of water (c) Modify rate of overland flow (d) Modify infiltration opportunity	) Protective) Effects) (1)
Excess precipitation produces overland flow and transports soil.	(a) Modify soil porosity (b) Modify soil permeability (c) Modify soil aggregation (d) Modify stability of structure	) Soil) Conditioning) Effects (2)
Excess precipitation produces rivulet, channel, and gully flow, causing cutting of soil mass.	(a) Modify soil moisture and amount of internal space	

¹Must be present during rain.
²Must be established before rain.

TABLE 2.--*Examples of the primary erosion control target*

RELATION OF RAIN INTENSITY TO EROSION IN NEW YORK[1]

Rains No.	Max. 15-Min. amount Inches	Erosion per storm Lbs.	Percent of total erosion
55	0.13	8	
29	.16	57	
33	.19	232	
12	.29	721	
27	.38*	1,594	
9	.54*	3,527	16.1)
10	.68*	5,704	31.9) 65
2	1.00*	14,427	17.7)

RELATION OF RAIN INTENSITY TO EROSION AT CLARINDA, IOWA[2]

Rains No.	Max. 15-Min. amount Inches	Erosion per storm Lbs.	Percent of total erosion
2			18
16			60
128			100

(54% of total erosion from corn occurs in May and June.
55% of total erosion from oats occurs in May.)

*Classed as ''excessive storms'' by Weather Bureau.

[1] Lamb, Andrews, and Gustafson. Cornell Bulletin 811. March 1944.

[2] Based on data in U. S. D. A. Tech. Bul. 959. October 1948.

probably could refine this classification somewhat and show the variation in intensity of rain that is required to produce erosion on soils differing in permeability and erodibility. This, however, can be developed now only in certain local areas where sufficient information is available.

The numbers of these excessive storms that occur in different months of the year have been shown by Yarnell.[2] An examination of his charts for the eastern part of the United States shows the high frequency of such storms occurring in Texas, Oklahoma, and Kansas in May, as well as in Florida and Alabama. In June a large number of these storms occur in Indiana, Arkansas, and Kansas. The charts clearly indicate that in different parts of the country in different months the expectation for excessive storms differs widely. The distribution of excessive storms by months for several States is shown in figure 1, page 5.

In designing erosion control measures, whether they be agronomic or another type, one of the most important considerations is to have the protection that is provided by the treatment coincide with the erosive forces in time and equal or exceed them in magnitude. For example, a good winter cover crop provides inadequate protection against erosion that occurs in midsummer. This is illustrated in figure 2, page 6, where peas for a canning factory are harvested in the season of most excessive storms--namely, mid-June. Any soil-conditioning effects of even excellent cover crops cannot provide protection against the high-intensity midsummer storms that usually produce the bulk of the annual erosion. It is obvious that between the time of pea harvest and that of attaining good ground cover by rye and vetch, some additional protection is essential. Whether this can be provided by crop residues left on the surface or by other means depends upon many local conditions and requirements. This figure serves merely to point out the need and perhaps the type of research that is needed.

Another example is outlined in figure 3, page 6. The most hazardous period is (1) June, (2) August, and (3) July. These are the months when the frequency of excessive storms is greatest where these farms are located. On farm A no protection is provided during the period of black fallow preceding wheat. During the wheat portion of the rotation, fair protection is offered after the wheat reaches the stage of providing a good canopy. Where the straw and stubble is left on the surface, this protection is continued. The following year a hazardous period appears from the time of seeding kaffir until it provides a good canopy.

On farm B, however, located in the same area, the alfalfa-brome mixture provides excellent protection throughout each hazardous period. In addition, it provides considerable soil conditioning against the future wheat year.

These instances are but examples taken from widely differing areas that point to the need for a careful examination of each local soil conservation problem. If the farm planner can first determine the specific circumstances under which the bulk of the erosion occurs, he is then in position, usually, to examine the dominant hazard in some detail. This may be snow, or wind, as well as rain--depending upon the conditions in different areas. The normal magnitude, time, and frequency of occurrence may be closely estimated. Once this is done, the target is more clearly identified. Treatments to meet the dominant needs may be designed with greater efficiency.

These procedures are applicable to research planning no less than they are to farm planning, because a good plan, among other things, requires a sharply defined objective.

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[2] YARNELL, D. L. Rainfall Intensity-Frequency Data. U. S. Dept. Agr. Misc. Pub. 204. 1935. (Although some inaccuracies are now known to exist in these charts, they are generally useful and applicable to broad examinations of rain intensities. Locally they may be refined in precision, particularly where there are long-time records of the local rainfall.)

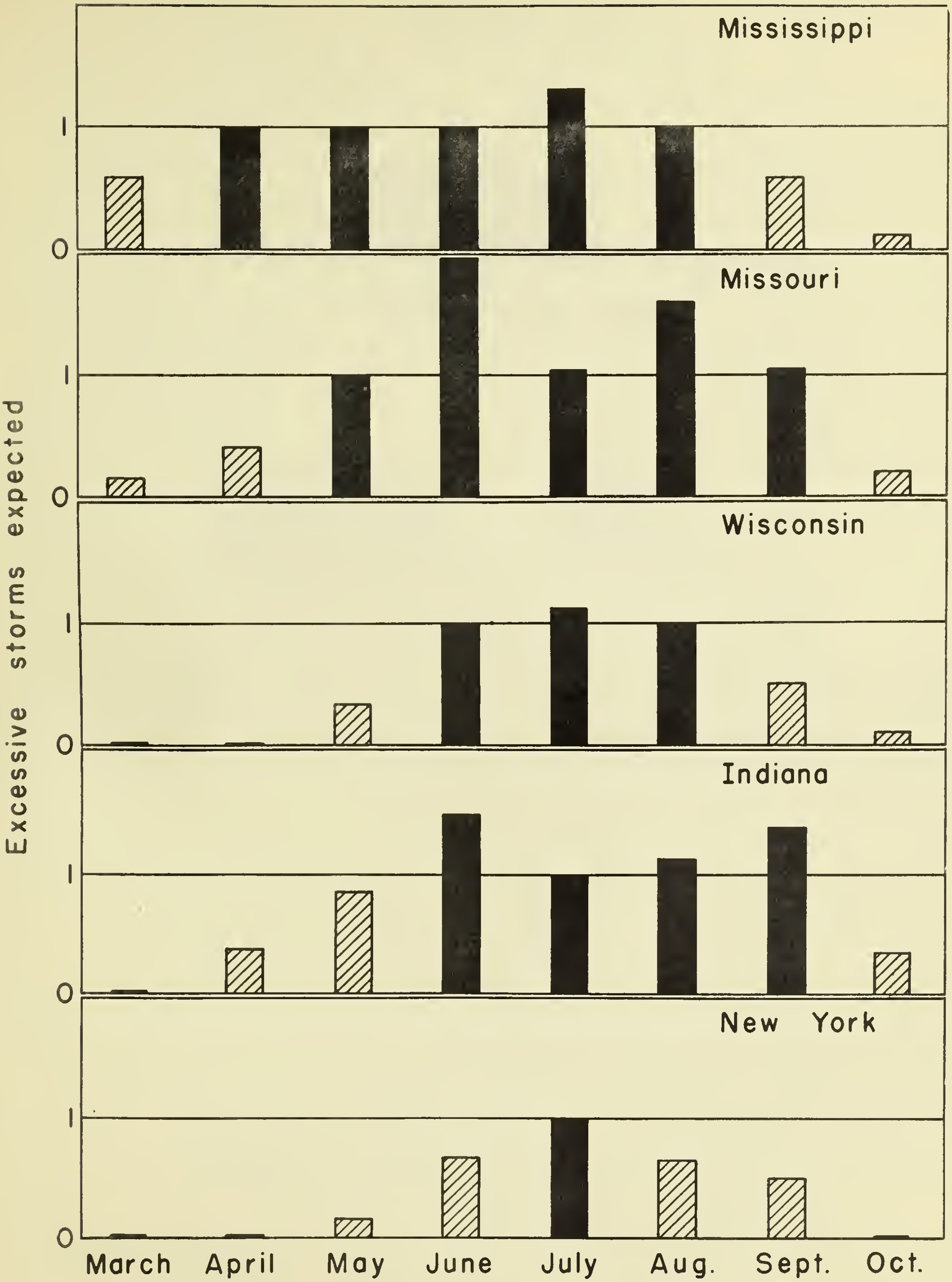

FIGURE 1.--The occurrence of excessive storms differs widely from month to month in different areas. These examples plotted from Yarnell's data show that the hazards from rainfall demand differing timing of protective measures from place to place.

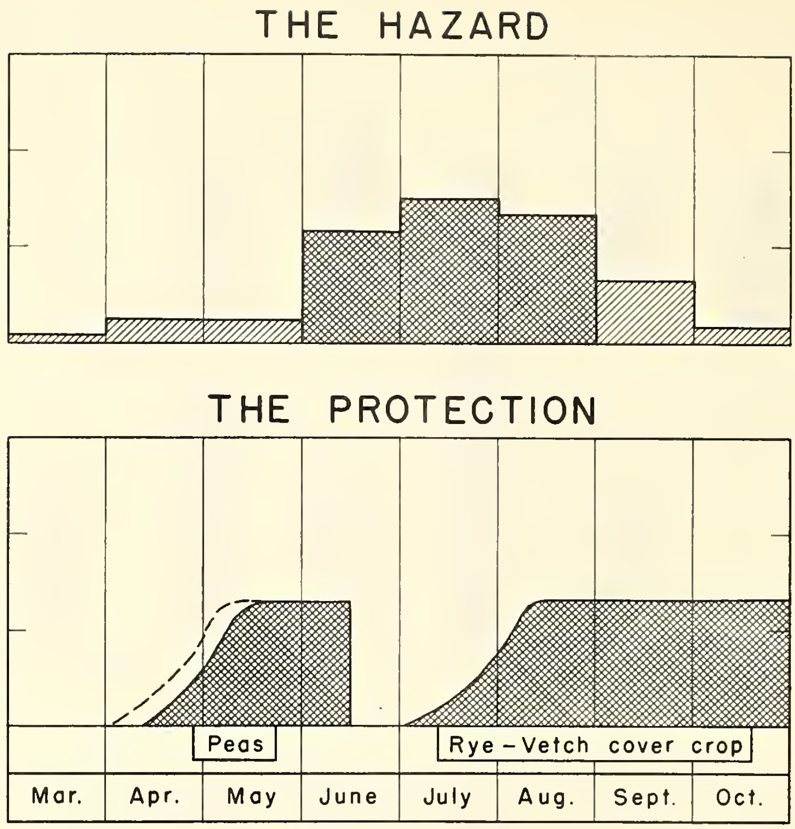

FIGURE 2.--Schematic outline illustrative of a gap in the protection provided by a crop in a rotation and the following winter cover crop. On this farm the application of organic matter, fertilizers, crop rotation, cover cropping, and contouring are not in themselves all-sufficient even though the slopes are mild and the soil relatively permeable.

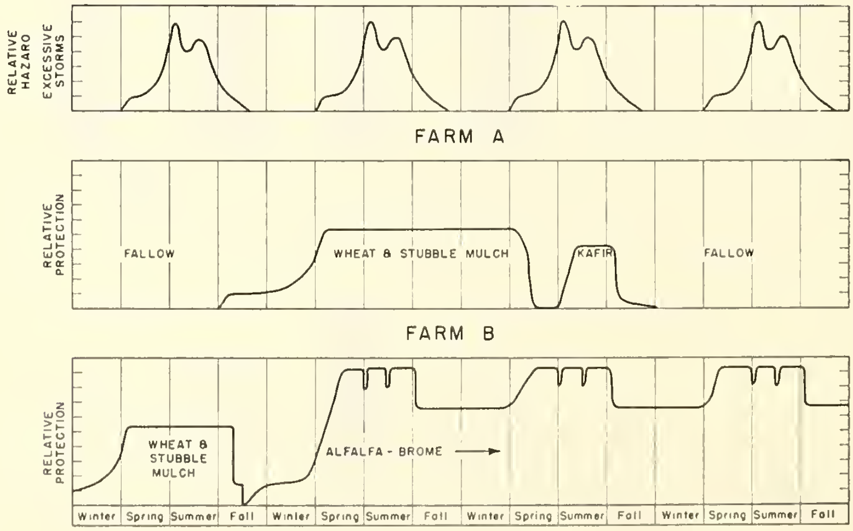

FIGURE 3.--Schematic outline illustrative of the occurrence of the hazard (excessive storms) and of the protection (obtained from agronomic practices) on two different farms in the same area during a 4-year period.

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